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THE LIFE HISTORY OF HABRONEMA MUSCÆ (CARTER), A PARASITE OF THE HORSE TRANSMITTED BY THE HOUSE FLY.

BY

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LETTER OF TRANSMITTAL.

United States Department of Agriculture,
Bureau of Animal Industry,
Washington, D. C., October 7, 1912.

Sir: I have the honor to transmit herewith for publication in the bulletin series of this bureau a manuscript entitled "The Life History of *Habronema muscæ* (Carter), a Parasite of the Horse Transmitted by the House Fly," by Dr. B. H. Ransom, Chief of the Zoological Division.

Respectfully,

A. D. Melvin,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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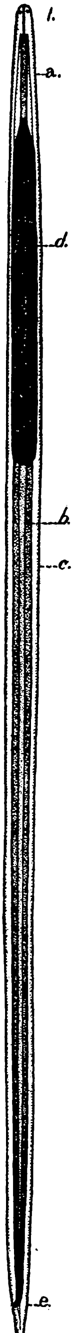
THE LIFE HISTORY OF HABRONEMA MUSCÆ (CARTER), A PARASITE OF THE HORSE TRANSMITTED BY THE HOUSE FLY.

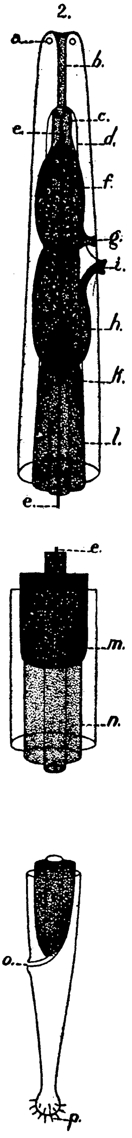
SUMMARY.

Over 50 years ago in Bombay, India, the late H. J. Carter discovered some larval nematode worms in the common house fly. These worms, known as *Habronema muscæ*, have since been repeatedly observed in flies in various parts of the world, but their life history remained a mystery which has only recently been cleared up through investigations made by the present writer. The results of these investigations show that the adult stage of the parasite occurs in the stomach of horses. The embryos produced by the parent worms in the stomach leave the body in the alimentary dejecta and enter the bodies of fly larvæ which have hatched from eggs deposited in the dejecta by house flies. The young worms grow and develop in the fly larvæ and reach their final stage of larval development at about the time the flies emerge in the winged state from the pupal stage. Finally they complete their development to maturity after the flies which they infest are swallowed by horses. In flies the parasites are commonly found in the head, frequently in the proboscis, but they occur also in the thorax and abdomen. The occurrence of these worms in a fly is positive proof that the fly was bred in horse manure, hence the frequency with which they are found in flies roughly indicates the extent to which horse manure in the neighborhood is serving as a breeding place for flies. The adult *Habronema muscæ* is very similar to *Spiroptera microstoma*, known since 1866 as a parasite occurring in the stomach of the horse, but is distinctly a different species. The two species, however, are congeneric, and the latter accordingly takes the name *Habronema microstoma*.

INTRODUCTION.

In a prior paper (Ransom, 1911) I have briefly reported some investigations which led to the discovery that *Habronema muscæ* (Carter), known since 1861 as a parasite of the house fly, is the larval stage of a parasite of the horse, closely related to *Spiroptera microstoma* (Schneider, 1866). These investigations indicate that the embryos of the parasite leave the body of the definitive host in the feces, enter the bodies of fly larvæ, reach their final larval stage shortly before or after the transformation of the flies into the imaginal state, and at last complete their development to maturity when the flies which





they infest are swallowed by horses. The life history of *Habronema muscæ* is thus of the type, not unusual, that involves a simple alternation between two hosts, one a vertebrate harboring the adult stage of the parasite, and the other an invertebrate harboring the larval stage.

HISTORICAL.

The first definite record of *Habronema muscæ* is that of Carter (1861), who found two nematode worms in the head of a house fly at Bombay, India, in November, 1859. In July, 1860, the same author made further examinations of flies at Bombay and found that on an average every third fly contained from 2 to 20 worms, located chiefly in the proboscis, but occasionally among the soft tissues of the head and posterior part of the abdomen. Carter erroneously considered these worms to be bisexual and mature. He gave them the name *Filaria muscæ*, and described them as follows:

> Linear, cylindrical, faintly striated transversely, gradually diminishing toward the head, which is obtuse and furnished with four papillæ at a little distance from the mouth, two above and two below; diminishing also toward the tail, which is short, and terminated by a dilated round extremity covered with short spines. Mouth in the center of the anterior extremity. Anal orifice at the root of the tail.
>
> Oesophagus commencing from a slightly dilated oral orifice, narrow at first, then becoming suddenly increased in caliber, and, after extending some distance backwards, joining the intestine, apparently without any line of demarcation, opposite the anterior termination of the hepatic organ. Intestine continued straight through the body, and nearly of the same size, on to the rectum, which is short and obliquely directed towards the anus. Oesophageal sheath [fig. 2] commencing at the termination of the narrow portion of the

FIG. 1.—*Habronema muscæ* from house fly. *a*, esophagus; *b*, intestine; *c*, "intestinal sheath;" *d*, "liver;" *e*, rectum and anus. Enlarged. After Carter, 1861 *b*, pl. 1 A, fig. 2. Erroneous interpretations of Carter indicated by quotation marks.

FIG. 2.—*Habronema muscæ* from house fly. *a*, head papillæ; *b*, "small part of esophagus;" *c*, large ditto; *d*, "esophageal sheath;" *e*, *e*, *e*, "dorsal vessel;" *f*, "ovary charged with nucleated cells;" *g*, "vulva;" *h*, "testicle charged with nucleated cells;" *i*, "penis;" *k*, "anterior extremity;" *l*, "anterior extremity of intestine;" *m*, "posterior end of liver;" *n*, intestine and "intestinal sheath;" *o*, rectum and anus; *p*, spinous extremity of tail. More highly magnified than fig. 1. After Carter, 1861 *b*, pl. 1 A, fig. 3. Erroneous interpretations of Carter indicated by quotation marks.

oesophagus posteriorly, where the latter is embraced by the dorsal vessel, gradually increasing backwards to join, without a line of demarcation, the sheath of the intestine, which, on its part, soon attaining its maximum caliber, is continued backwards, of the same size, to the termination of the hepatic organ, where it becomes slightly but suddenly reduced in diameter and afterwards maintains nearly the same size on to the rectum.

Hepatic organ [fig. 1, *d*] marked by a dense white layer of oil globules and granular matter wthin the intestinal sheath, surrounding the anterior third of the intestine, commencing opposite the union of the latter with the oesophagus, and terminating at the sudden diminution in diameter of the intestinal sheath, where it is defined by a circular line (*m*). Rectum (*o*) more or less obscured by muscular and other structure, in the midst of which two glandular bodies are observed opposite its junction with the intestine. Dorsal vessel (*e e e*) extending from the point of union between the smaller and larger portions of the oesophagus (*e*), which it embraces by bifurcation, to the posterior end of the hepatic organ (*m*), where it again appears to bifurcate and to embrace the intestinal sheath.

Generative organs situated in the anterior part of the body, under the oesophagus and anterior part of the intestine, consisting of an ovary [fig. 2, *f*] and testicle (*h*), opening on the right side, a little in front of the liver, by separate ducts about one-hundredth of an inch apart, the former, which is anterior, by a simple papillary aperture (*g*), and the latter by the same, but with a short funnel-shaped exsertile organ (*i*). Ovary unseen in detail, but charged with nucleated cells, and presenting a distinct line of demarcation between itself and the testicle, which on its part appears to be saccular, and also contains nucleated cells that are sometimes spermatophorous. Spermatozoa indistinctly seen; single, in cells about 1-700th of an inch in diameter; consisting, when half developed, of a striated, pyramidal or triangular body growing out of a small mass of granular mucus on one side of the cell; when fully developed apparently club-shaped.

Size. About 1-11th of an inch long and 1-313th of an inch in its broadest diameter—that is, in the middle.

Hab. Proboscis, head, and posterior part of the abdomen of the common house fly (*Musca domestica*).

Loc. Island of Bombay.

In some of its details Carter's description is rather faulty, and some of the interpretations placed on observed structures are quite wrong. For example, the "narrow portion" of the esophagus is the pharynx, and the "hepatic organ" is part of the esophagus and not a structure surrounding the anterior third of the intestine. The "dorsal vessel" is apparently one of the lateral lines, or perhaps the lumen of the esophagus. The "ovary" and "testicle" are misinterpretations of a mass of cells located in the anterior esophageal region, probably belonging to the nervous system. The genital ducts and pores described by Carter are apparently misinterpretations of the excretory pore and canals.

Among the observations Carter notes that he has not seen the ova in their fully developed state, and that he is—

ignorant of the future of this worm; but knowing that many Entozoa are nursed in one animal and lay their eggs in another, it is not improbable that

> this part of the cycle of their development may be performed in the alimentary canal of the white "Paddy bird" or crane (*Ardea modesta*), which appears to live chiefly on the common house fly, being a constant attendant for this purpose on cattle, and at the slits made in the palm trees for the extraction of their saccharine juice.
>
> To ascertain if *F. muscæ* would live in sugar and water, in water alone, and in the former, to which in one instance *gum acaciae* had been added, and in another a portion of gelatinized *Nostoc*, both to serve as a nidus to nestle in and for nourishment, several of these worms were transferred to these media, respectively, in watch glasses sheltered in a glass case, but none survived more than a few hours, whether from change of habitat or change of nourishment (which latter could not be very different from that taken in by the fly, unless a secretion from the fly itself), I am ignorant.

The next mention of Carter's species was made by Diesing (1861 *c*, pp. 273–274), who on the basis of the original description took the worm as the type of a new genus which he called *Habronema.*

Leidy (1874 *d*, pp. 139–140) noted that *Habronema muscæ* occurred in about 20 per cent of flies examined at Philadelphia, Pa.

Ercolani (1874 *a*, pp. 251–252) noted that when a young man he had frequently found in the summer time a species of agamous nematode living in the proboscis of flies. Later he made further observations, without, however, identifying these worms with the form described by Carter, of whose work he was probably unaware. He describes them as somewhat over 2 mm. long, with a body attenuated posteriorly, measuring 0.07 mm. in width anteriorly, and only 0.03 mm. in width toward the tail. The mouth, according to Ercolani, is round and furnished with six teeth or slender papillæ, and the anus is 0.01 mm. from the tip of the tail. Ercolani's assistant, Piana, placed some of the worms from flies in moist earth, but this experiment was without result.

Linstow (1875 *a*, pp. 195–197), having had his attention called to the occurrence of nematode larvæ in the head of *Stomoxys calcitrans*, examined 41 heads of these flies and found nematodes in two, in one case 1 embryo and 5 larvæ and in the other 1 larva. They occurred in the musculature between the proboscis and the proboscis sheath. The embryo (fig. 3) was 0.27 mm. long and 0.01 mm. wide. The head was enlarged, knob-like, with two lateral papillæ, between which there was an awl-like spine. The esophagus was relatively very long; ratio between its length and that of the body 1 to 2.7. The intestine was thinner than the esophagus, brownish in color, with numerous dark granules. The body elsewhere was colorless. Anus absent. The tail was elongate conical, with bluntly rounded tip. In the esophageal region the cuticle was supplied with 2 rows of punctiform papillæ (9 in each row) on the ventral side of the body, only clearly visible when the body was turned in certain positions. The larvæ (figs. 4, 5) were 1.6 to 2 mm. long by 0.05 to 0.059 mm. broad. The mouth showed 3 slight swellings, with two small papillæ on each. The esophagus consisted of an anterior short portion [pharynx], 0.05 mm. long, which was enlarged at the mouth to form a funnel-shaped vestibulum, and a posterior portion, about twice as thick as the anterior portion, with a very muscular wall supplied with numerous small nuclei. The esophagus was relatively long, eleven-sixteenths the length of the body. The intestine was yellowish in color, thinner than the esophagus, and composed of polygonal cells. The anus was 0.07 mm. from the tip of the tail. The posterior end of the intestine was supplied with prominent cylindrical granular gland cells. The tail was gradually attenuated and the tip supplied with very fine rounded spines or papillæ arranged very close together.

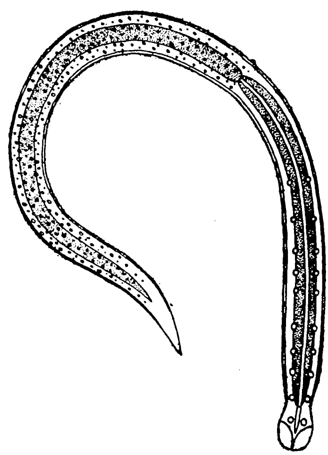


FIG. 3.—*Filaria stomoxeos* (embryo) from stable fly (*Stomoxys calcitrans*). Enlarged. After Linstow, 1875 *a*, pl. 3, fig. 22.

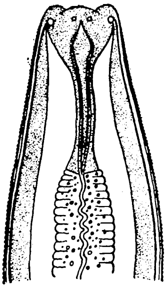


FIG. 4. — *Filaria stomoxeos* (larva). Anterior end. Enlarged. After Linstow, 1875 *a*, pl. 3, fig. 20.

Linstow at first believed that he had specimens of *Habronema muscæ*, but in view of the fact that the worms from *Stomoxys* were without sexual organs, had six oral papillæ, and lacked the globular swelling on the tip of the tail, whereas *H. muscæ* as described by Carter was sexually mature, had 4 oral papillæ, and had a spiny globular swelling on the tip of the tail, Linstow concluded that the form from *Stomoxys* was a different species and called it *Filaria stomoxeos*. Although Linstow considered the embryo which he found in *Stomoxys* to be of the same species as the larvæ, this is by no means certain. Noè (1903 *a*, p. 392) states that the *Filaria stomoxeos* of Linstow is the same as the nematodes found by him in *Stomoxys*, which he considered to be intermediate stages of *Filaria labiato-papillosa* of cattle. Noè's statements have been commonly accepted, but as a matter of fact it is impossible to judge definitely from the data given whether or not he is correct in his opinion as to the identity of the nematodes and as to their being intermediate stages of *Filaria labiato-papillosa*. From Linstow's description, however, it would appear that *Filaria stomoxeos* closely

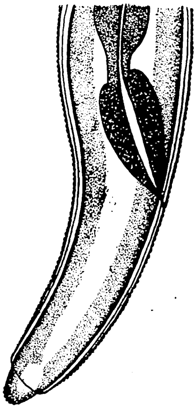


FIG. 5.—*Filaria stomoxeos* (larva). Posterior end. Enlarged. After Linstow, 1875 *a*, pl. 3, fig. 21.

resembles *Habronema muscæ*, and one would be inclined to consider it a species of *Habronema* rather than the larva of *Filaria labiato-papillosa.* The possibility is not excluded that *Filaria stomoxeos* is the larval stage of *Habronema microstoma* (Schneider, 1866).

Bartram (1880 *a*) noted the occurrence of small worms resembling vinegar-eels in the heads of house flies and wrote to the editor of the American Journal of Microscopy inquiring as to their identity.

Generali (1886 *d*), at Modena, Italy, noted the occurrence of nematodes in house flies, stating that he has not succeeded in finding them in other species. The frequency of occurrence, based on an examination of 250 flies during the summer of 1884, was 12.6 per cent. Ordinarily he found but one, rarely two, in the same fly; once he found three, and once four. The parasites were located in the head. They appeared to be larval stages. The size given was 1 to 1.5 mm. in length and 40 to 50 µ in width. They are extraordinarily active when removed from the fly. In salt solution (1 to 1,000) they continue very active during the first 24 hours; during the following day their movements become slower; on the third day they move slowly; on the fourth day their movements practically cease. A larva from which the water in which it was immersed had evaporated became motionless, but five or six minutes after the addition of more water resumed its movements, which continued for several hours. Generali states that it is conceivable that the parasites during their embryonic stage penetrate into the fly, but that he had found only the one stage of development.

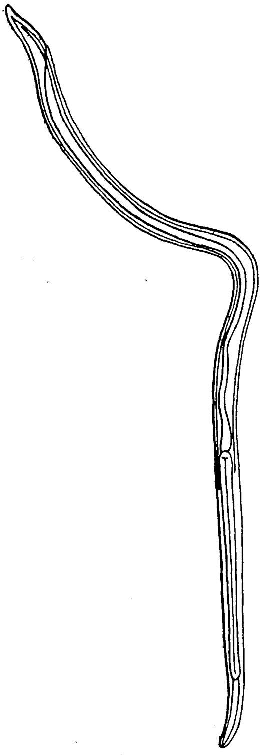


FIG. 6.—*Habronema muscæ* from fly. ×44. After Piana, 1897 *a*, fig. 15.

Presumably the nematodes found by Generali were *Habronema muscæ*, although the final larval stage of this species is much longer than 1 to 1.5 mm., the figures given by Generali. This discrepancy, however, is probably the result of an error in measurement and is insufficient to justify one in concluding that Generali's nematodes were not *Habronema muscæ*.

Piana (1897*a*) in connection with a study of *Dispharagus nasutus* was led to examine nematodes found in the heads of flies in order to determine whether they might not represent larval stages of the *Dispharagus*. The fly nematodes (figs. 6–8), he remarks, may be found by preparing the proboscis of the common fly in water under the microscope, but it is not always easy to find them. He notes that in certain localities and at certain stages of the fly's life the flies harboring nematode larvæ in the proboscis are, to say the least, very rare, but that in other localities and at other stages infested flies are found at the rate of 20 to 30 per cent. He observed that when the larvæ are freed from the fly's proboscis they begin to swim so rapidly in a serpentine manner that it is impossible to make out anatomical details. By poisoning them with nicotine he rendered them motionless without sensibly altering their structure. A larva thus narcotized measured 2.68 mm. long and 0.08 mm. broad. The form was cylindrical, tapering gradually toward the extremity. Width, at a distance of 0.036 mm. from the mouth, 0.036 mm.; width in the anal region 0.031 mm.; anus 0.10 mm. from the tip of the tail. Tip of the tail blunt, with a transverse diameter of about 0.010 mm. The two buccal lips found in *Dispharagus nasutus* are absent. The digestive tract presents the same divisions as that of *D. nasutus;* but at the point of union of the second and third sections there is a slight dilatation of the lumen not seen in *Dispharagus*. The tail, although very similar to that of *Dispharagus nasutus*, has a relatively larger apex, and a terminal surface covered with minute chitinous points. In view of the difference between the nematodes of the fly and young stages of *Dispharagus nasutus* from chickens, Piana concluded that the two were not related. Piana observes that the nematodes which he found in flies in their general conformation and in the structure of the caudal end of the body are very similar to those described by Carter. Considering the similarity between the nematodes found by Piana as described and figured by him and *Habronema muscæ* as described and figured by Carter, and considering also the fact that they were found in the same host it is fair to assume that they are the same species, just as I have assumed that the nematodes which I have found in flies belong to Carter's species.

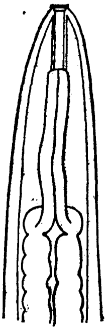


FIG. 7.—*Habronema muscæ* from fly. Anterior end. × 220. After Piana, 1897 *a*, fig. 16.

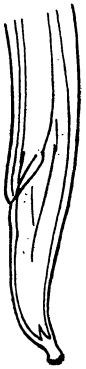


FIG. 8.—*Habronema muscæ* from fly. Posterior end. × 220. After Piana, 1897 *a*, fig. 17.

AUTHOR'S OBSERVATIONS.

FREQUENCY OF LARVÆ IN FLIES.

ADULT FLIES.

One hundred and thirty-seven flies, of which a statistical record was kept, have been examined by the present writer for the presence of *Habronema;* 39 of these, or 28 per cent, were infested; 4 out of 27 examined at Washington, D. C., were infested; 30 out of 91 at Colorado Springs, Colo., were infested; and 5 out of 19 at Bancroft, Nebr., were infested. Numerous other flies were examined, among which infested individuals were commonly encountered, but statistical records of the frequency of the parasites were kept only in the case of the flies referred to above.

Carter, it will be remembered, found that on the average one out of every three flies examined in Bombay were infested, and Leidy found that in Philadelphia one in five was infested. As suggested in my preliminary note on the life history of *Habronema*, a rough index of the relative number of flies breeding in horse manure in a given locality may be obtained by examining a large number for the presence of *Habronema.* As the finding of larvæ of *Habronema* in a fly indicates definitely the character of the breeding place of that fly the percentage of flies found to be infested will also represent the percentage of flies definitely known to have been bred in horse manure. The true percentage of flies bred in horse manure will, of course, always be higher than that of infested flies found, provided a sufficiently large number of individuals are examined to avoid coincidental errors, first, because larval worms in some of the flies examined are likely to be overlooked; second, because it is unlikely that every fly bred in infested horse manure will become infested; and third, because not every horse may be infested. An approximation to the true percentage would, however, be possible in case further investigations should show that the number of infested flies found bears a more or less constant ratio to the number of flies of horse-manure origin, as determining by examining various lots of flies bred in cages from horse manure; and though it is perhaps improbable that any such ratio exists, owing to the several uncertain factors involved, still it is not impossible.

In any event, however, it is an interesting fact that by examining a number of flies captured it matters not where one may know positively that those in which *Habronema* larvæ are found were bred in horse manure, even though one can not be certain that some or all of those not found infested did not have a similar origin.

PUPÆ.

Altogether 137 pupæ of which a statistical record was kept have been examined for the presence of *Habronema.* Most of these had developed from fly larvæ which had bred in horse manure, but many of them were from larvæ which had bred in other materials; 23, or 17 per cent, were found to be infested. A considerable number of cases of infestation probably escaped detection on account of the fact that the parasites in their younger stages are very easily overlooked.

LARVÆ.

One hundred and seventy larvæ were examined, 28 of which may have been of some species other than the house fly, and of 13 of which in an experiment had fed only on boiled horse manure. Of these 170 larvæ only 1 was found to be infested. This small number of infested larvæ found is explained by the fact that it is extremely difficult to discover the young stages of the parasite, a difficulty which is greatly aggravated by the common occurrence of numerous small nematodes of several species on the surface of the body and more rarely in the alimentary tract of fly larvæ.

NUMBER OF LARVAL WORMS IN INDIVIDUAL FLIES.

ADULT FLIES.

Carter noted as many as 20 worms in one fly. The most which I have found is 8. Out of 43 flies of which a record as to the number of parasites was kept 25 had but 1 parasite, 6 had 2 parasites, 6 had 3 parasites, 3 had 4 parasites, 2 had 5 parasites, and 1 had 8 parasites.

PUPÆ.

In 23 infested pupæ 1 worm was found in 15, 2 worms in 5, 3 in 1, 4 in 1, and 5 in 1.

LARVÆ.

In 1 larva a single encysted worm was found.

LOCATION IN THE BODY.

ADULT FLIES.

A record was made of the location of the parasites in the case of 37 flies. In 17 cases the head was infested, in 8 cases the thorax, and in 19 cases the abdomen. In 12 cases the head only was infested, in 4 cases the thorax only, and in 15 cases the abdomen only. Simultaneous infestation of the head and thorax occurred in 2 cases, of the head and abdomen in 1 case, of the thorax and abdomen in 2 cases, and of the head, thorax, and abdomen in 1 case. The number of worms in the head was 1 in 11 cases, 2 in 1 case, 3 in 1 case, 4 in 2 cases, 5 in 1 case, and 6 in 1 case. The number in the thorax was 1 in 5 cases and 2 in 3 cases. The number in the abdomen was 1 in 11 cases, 2 in 4 cases, 3 in 3 cases, and 5 in 1 case. Encysted larvæ were found in the abdomen in 6 flies, in 5 of which no worms were present in either the head or thorax; in the remaining fly there were larvæ in both the head and the thorax. All of the flies in which encysted larvæ were found were flies which had recently emerged. In 4 of the cases in which the head was infested it was noted that larvæ were present in the proboscis, 5 in 1, 4 in another, and 1 in the remaining 2 cases.

PUPÆ.

The distribution in the case of 9 pupæ in which the location was recorded was as follows:

Abdomen infested 9 times, head once, thorax once. Simultaneous infestation of the head and abdomen and of the head and thorax occurred once each. Encysted worms were found in 11 out of 23 infested pupæ, and in all cases in which the location was recorded these were located in the abdomen.

EXPERIMENTS WITH LARVÆ REMOVED FROM FLIES.

In August, 1909, 10 *Habronema* larvæ taken from flies caught in the laboratory of the Zoological Division of the Bureau of Animal Industry at Washington, D. C., were placed in a culture medium composed of water and horse feces which had been sterilized by boiling. Two days later the worms were all quiescent and apparently dead. June 10, 1910, 5 larvæ from the proboscis of a fly were placed in tap water. The following day 4 of them were still alive, but all were dead a day or two later. June 13, 1910, larvæ from dead flies were placed in a dish containing water and the remains of the dead flies. These larvæ were still alive on the following day, but succumbed within two days. Two larvæ placed in a moist cell with horse feces, June 22, 1910, died within a few days. A few other similar experiments were carried out, the details of which can not be given, as the notes on them have been lost. In every case, however, the worms died within a very few days without undergoing any further development. The longest period of survival noted was between 5 and 8 days, in the case of a larva removed from a fly January 3, 1912, and placed in physiological salt solution. The worm was still alive January 8, but was dead January 11. From these experiments it appears that the larvæ are able to exist for only a limited period when removed from their host, thus confirming the results of the experiments made by Carter, who found that the worms lived but a few hours in culture media of water, sugar and water, sugar and water with gum acacia added, and sugar and water with gelatinized *Nostoc* added. As no indications of any further development of the worms were noted in any of the experiments, attempts to grow the worms in cultures were abandoned early in the investigations.

SURVIVAL OF LARVÆ IN DEAD FLIES.

Three flies which died June 10 or 11, 1910, were examined June 13 and found to contain living larvæ. It is thus evident that the worms may survive in flies at least two days after the death of their host.

Dead flies were not noticed in the stomachs of two horses examined at Omaha in September, 1911, but in one of them several fly pupæ were observed. If horses swallow fly pupæ, the chances of their swallowing dead flies seem equally good, and hence it seems quite certain that dead infested flies are an occasional, perhaps a common, source of infection.

ESCAPE OF LARVÆ FROM FLIES.

June 14, 1910, an active larva was observed in the moisture in the bottom of a jar in which some flies had been confined since the day before. Many of the flies were dead, and it is therefore uncertain whether the worm escaped before or after the death of its host, and it is also uncertain whether the host fly had not been injured in such a way as to provide an exit for the worm.

The escape of larvæ from flies into water or into moist material liable to be ingested by horses is a possible mode by which infection of the final host may occur, but the fact that the worms, so far as observed, are unable to live more than a few days outside the body of a host goes to prove that this is not a normal occurrence in their life history.

The fact that the proboscis is a favorite location of the larval worms suggests that they may abandon their intermediate host in some such manner as *Filaria* larvæ abandon the mosquito. It is conceivable that they might escape through a slight rupture of the proboscis occurring at a moment when the fly was sucking moisture from the mucous membrane of a horse's lips, after which they could readily reach their final location, the stomach. As yet, however, no evidence of such an occurrence has been obtained.

DEVELOPMENT.

EMBRYOS.

The eggs of *Habronema muscæ* as seen in the uterus of the gravid female, in the earliest stage of development are elongated with very thin shells, 40 to 50µ long by 10 to 12µ wide. With the progress of development of the embryo they become longer. At a stage shown in figure 9, *e*, in which the embryo is doubled on itself head to tail, the egg measures 80µ in length by nearly 12µ in width, and at a little later stage (fig. 9, *f*) in which the embryo has straightened out, becoming also shorter, the eggshell measures 87µ in length and of about the same width as before. Later the shell becomes rather closely applied to the body of the embryo except on one side in the posterior region where it is held away by the curving tail. The embryo (fig. 9, *g*, *h*, *i*) now measures 85 to 100µ in length by 5 to 7µ in width. The anterior end is rounded. The thickness of the body is nearly uniform, except that it begins to taper in the posterior third, terminating in a pointed tail which curves forward and holds the shell or sheath of the worm away from the body as already noted. A small nucleus is rather conspicuous, located 35 to 40μ from the anterior end, and another one is quite commonly to be seen about 15μ from the tip of the tail. The contents of the body are finely granular. The alimentary canal has not been made out.

The embryos are active and motile when alive. Undoubtedly they pass out of the body of the horse in the feces. Whether they undergo further development before entering fly larvæ has not been determined, nor has it been determined whether they forcibly enter the intermediate host or whether they are passively swallowed. The latter seems the more plausible.

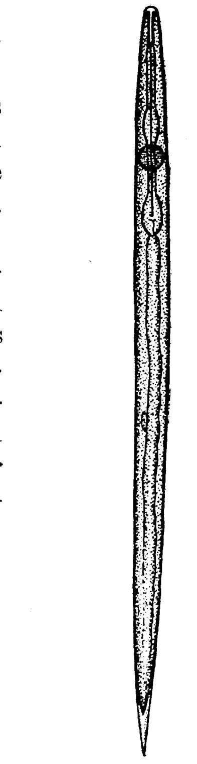


FIG. 10.—Rhabditiform nematode embryo (? *Habronema muscæ*) from fly larva. × 320. Original.

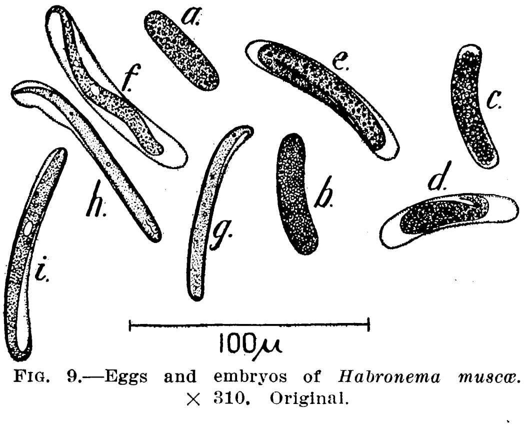


FIG. 9.—Eggs and embryos of *Habronema muscæ*. × 310. Original.

Embryonic stages definitely recognized as belonging to *Habronema muscæ* have not been found in fly larvæ. A rhabditiform embryo was found August 23, 1911, in a fly larva from a culture of horse feces collected August 9. This embryo (fig. 10), in process of molting, measured 275μ in length by 13μ in width. The slender cylindrical pharynx was 15μ long. The esophagus, 75μ long, had a toothed posterior bulb, and an enlargement just in front of the middle. Just behind this enlargement there was a conspicuous nerve ring. The genital primordium was 160μ from the anterior end. It is possible that this was an embryo of *Habronema*; but this has not been proved. The common occurrence of nematode embryos, and of small free living adult nematodes as well, on the exterior surface of the body of fly larvæ renders a search for internal parasites very difficult, in view of the fact that one can not always be sure that nematodes found in dissecting the larvæ did not come from the exterior of the body. To a certain extent there is a similar difficulty in the case of pupæ and adult flies, but here the fact that the parasites have already developed to a considerable size enables one to distinguish them from the small embryos which come from the exterior.

LARVÆ.

Stage 1.—The earliest stage in flies known definitely to belong to *Habronema* was first found in a pupa from a culture of horse feces collected in a fresh state from the streets of Colorado Springs, August 9, 1911. The pupa was examined August 22, and hence was not over 2 weeks old. The parasite (fig. 11) measured about 450μ in length by 45μ in width. It had a shallow pharnyx or mouth cavity, followed by a simple esophagus 160μ long, which increased from a width of less than 10μ anteriorly to a width of 20μ at its posterior end. At a distance of about 70μ from the anterior end of the body the esophagus was surrounded by a nerve ring. The intestine at first exhibiting an enlargement 30μ in diameter, soon diminished to a diameter of 20 to 25μ, a size approximately maintained until it joined the almost spherical or pyriform rectum, which measured about 30μ in diameter. The wall of the rectum exhibited a sort of foam structure. The anal opening was closed, and a rounded projection occurred at this point. The body at the anus measured about 40μ in thickness, and tapered suddenly to the blunt tip of the tail, which was about 40μ from the anus. Comparatively large, prominent nuclei were distributed throughout the body, in the esophagus, intestine, and body wall.

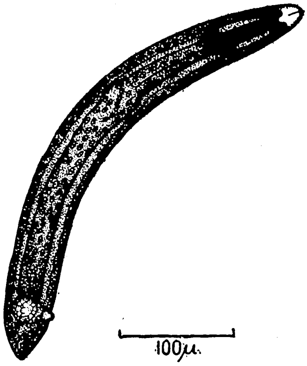


FIG. 11.—*Habronema muscæ.* Larva (Stage 1) from fly pupa. × 150. Original.

The larva was in process of molting or about to molt, and the old cuticle separated somewhat from the body was visible at the anterior end.

Later, that is, on August 26, a nematode in the same stage of development, and of the same structure, about 400μ long by 40μ thick, with an esophagus about 140μ long, was found in a fly larva from the same culture. This nematode was contained in a thin-walled spherical cyst, and it is probable that the worm found in the pupa was also encysted.

Stage 2.—The development from stage 1 into the next stage consists principally in an increase in length without much change in width and in a slight change in the structure of the oral end. The stage designated as No. 2 is shown in figure 12. The worm here figured was found in the abdomen of a pupa, August 26, which had developed in a culture of horse feces collected August 9. This worm was inclosed in a thin-walled cyst. As in the preceding stage, numerous small nuclei are conspicuous in the body wall and alimentary tract. The length of this worm is nearly 1 mm. and the maximum width about 50μ. The esophagus instead of immediately following the small oral cavity is now separated from it by a very slender pharynx about 12μ long. A clear space surrounds the pharynx, and extends to the body wall. The esophagus has the same structure as in the preceding stage but is longer, its base being about 300μ from the anterior end of the body. It is surrounded by a mass of nuclei in the second one-fifth. The intestine is enlarged at its origin, then diminished to a diameter of about 25μ, which is maintained until it joins the rectum, which is about 30μ in diameter. Nuclei like those seen in the wall of the remainder of the alimentary tract are absent from the rectum. The anus is closed and presents a rounded projection as in stage 1. Against the wall of the intestine about 600μ from the anterior end of the body there is an elongated

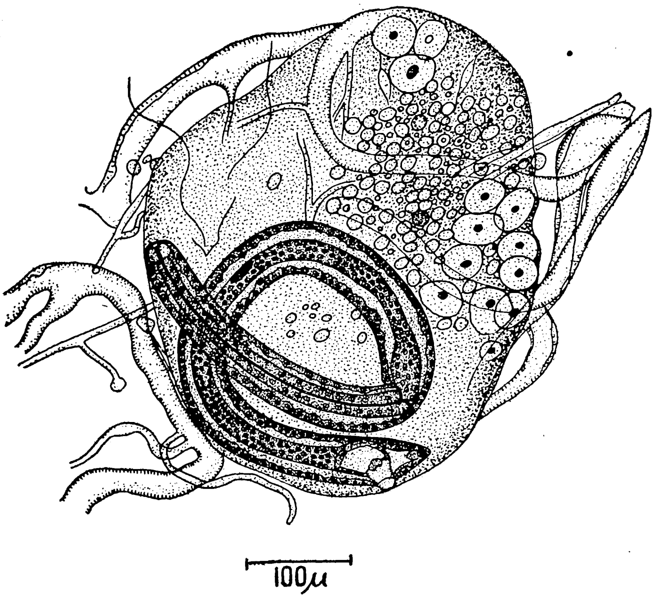


FIG. 12.—*Habronema muscæ.* Larva (Stage 2) inclosed in a cyst, from abdomen of fly pupa. × 140. Original.

nucleated mass, about 30μ long, evidently the genital primordium. The tail of the worm is bluntly pointed as in stage 1, and the anus is about 45μ from the tip.

Stage 3.—Following stage 2 the parasite evidently sheds its skin and abandons its cyst. It increases in length and in thickness. The prominent nuclei of the alimentary tract and body wall are no longer evident, the esophagus shows a differentiation into two parts, a shorter, narrower, more transparent anterior portion and a longer, thicker, granular posterior portion, and the pharynx becomes longer. Stage 3 is shown in figures 13, 14. The worm figured was taken from the abdomen of a newly emerged fly August 30 which had been bred in a culture of horse feces collected August 9. This worm measured about 2.2 mm. in length by about 70μ in width, which was nearly uniform throughout most of its length, becoming slightly less toward the anterior end. The slender pharynx measured about 38μ in length and was surrounded by clear spaces. The anterior clear portion of the esophagus measured about 100μ in length by 15μ in diameter, and at its junction with the second portion of the esophagus was surrounded by a nerve ring. The second portion of the esophagus at its beginning was enlarged rather suddenly to a diameter of 25μ and then more gradually to a maximum of about 32μ near its posterior end. In the neighborhood of the nerve ring the end of the first portion and the beginning of the second portion are surrounded by a mass (about 100μ long) of promi-

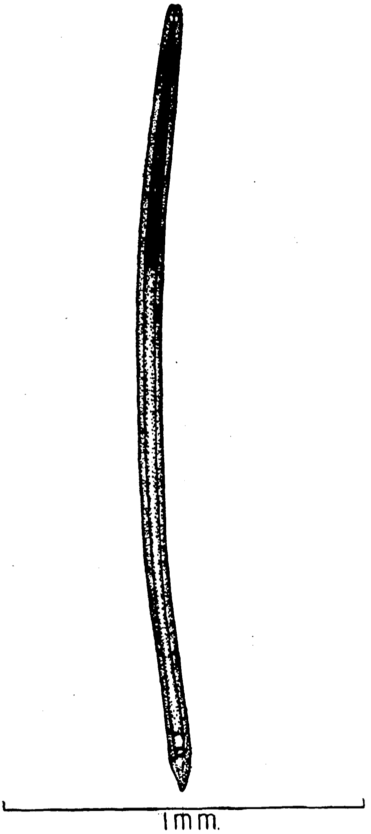


FIG. 13.—*Habronema muscæ.* Larva (Stage 3) from abdomen of newly emerged fly. × 47. Original.

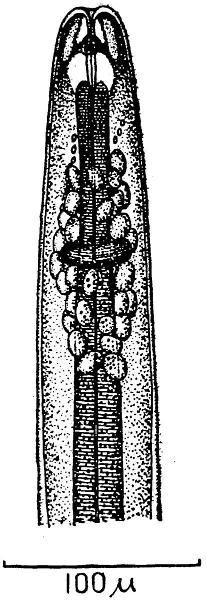


FIG. 14.—*Habronema muscæ.* Larva (Stage 3) from abdomen of newly emerged fly. Anterior end of worm shown in fig. 13. × 250. Original.

nent large nuclei. The posterior end of the esophagus was about 720μ from the anterior end of the body. The intestine, about 30μ in diameter, varied little in size until the rectum was reached. The rectum was short, slightly larger than the intestine and, as in preceding stages, was closed to the exterior by a rounded operculum-like structure which projected outward at the anus. The anus was about 100μ from the tail, which diminished gradually in thickness from the anal region and terminated in a rather blunt point. This worm was about to molt, as an outer and an inner cuticle were plainly evident in certain regions of the body.

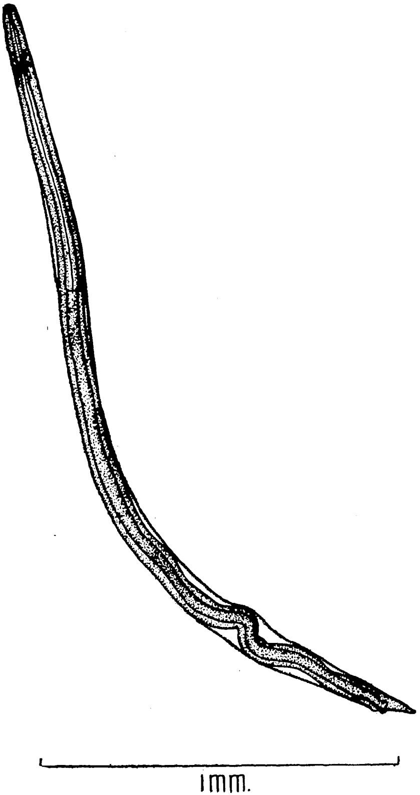


FIG. 15.—*Habronema muscæ.* Larva (Stage 4) from abdomen of newly emerged fly. × 47. Original.

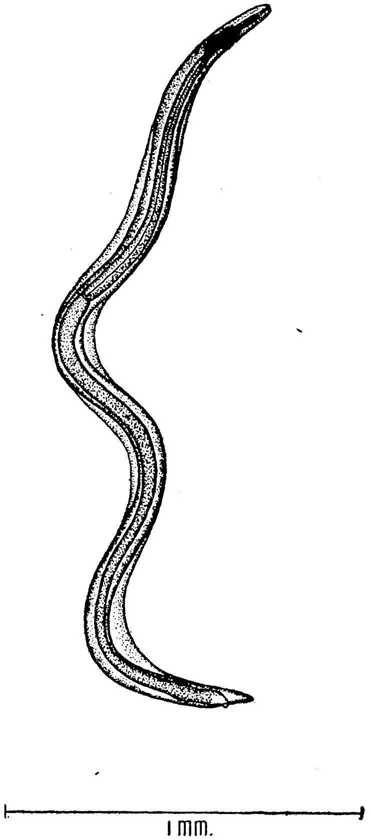


FIG. 16.—*Habronema muscæ.* Larva (Stage 5) from thorax of newly emerged fly. × 46. Original.

Stage 4.—Between stages 3 and 4 another molt evidently occurs. The vacuoles surrounding the pharynx disappear and the esophagus increases slightly in length. The entire worm becomes somewhat longer. The anal operculum remains. The worm shown in fig. 15 was taken August 25 from the abdomen of a newly emerged fly bred in horse feces collected August 9. The length, not allowing for the curved condition of the worm inside the outer cuticle, is about 2.2 mm. and the maximum width about 70μ. The pharynx, which is now no longer closed as in preceding stages, measures about 45μ in length. The posterior end of the esophagus is about 800μ from the anterior end of the body, both the anterior and posterior portions being slightly longer than in the preceding stage. The nerve ring is about 170μ from the anterior end of the body. Four small papillæ are evident on the head. The anus, still closed, is about 80μ from the tip of the tail, which is similar in shape to that of the preceding stage. The worm is about to molt.

Stage 5.—This stage follows stage 4 after an intervening molt. The pharynx is not so widely open, the esophagus is longer, the entire worm is somewhat longer and thicker, and the spiny tail, a constant feature of the next following stage, becomes evident beneath the outer cuticle. The length of the worm shown in figure 16, which was taken August 28 from the thorax of a newly emerged fly bred in horse feces collected August 9, is about 2.5 mm. The maximum breadth is about 75μ. The length of the pharynx, whose cylindrical cavity is somewhat narrower than in the preceding stage (fig. 15), is about 45μ. The posterior end of the esophagus is about 1 mm. from the anterior end of the body, both portions of the esophagus, but particularly the posterior portion, being somewhat longer than in the preceding stage. The same is still closed, and is about 80μ from the tip of the tail. Just prior to the molt which leads to stage 6, the spines, characteristic of the final larval stages, appear on the tip of the tail beneath the outer cuticle. The rectum is distended as in all the preceding stages.

Stage 6.—In flies: In this stage, which is the final larval stage, and the stage which the worms are usually in when found in the head or proboscis of infested flies, the length varies from 2.6 to 3.2 mm. and the width at the widest part from 55 to 70μ. The width is nearly uniform in the region between the beginning of the second part of the pharynx and the middle of the body, tapering posteriorly and at the anterior end. The head is rounded, and the tail pointed with a small rounded tip ornamented with tiny spines (fig. 19). Small papillæ, at least four and apparently six in number, may sometimes be made out on the head. The pharynx is cylindrical, about four times as long as broad. The anterior portion of the esophagus is less than half the average width of the posterior portion and about one-fourth the length of the latter. The anus in this stage is no longer closed. The worm shown in figures 17 and 18, taken August 28 from the head of a newly emerged fly bred in horse feces collected August 9, measures about 3 mm. in length. The pharynx is 45μ long by 12μ in width. Width of body at base of pharynx, 50μ; nerve ring 150μ from the anterior end of body; diameter of body at nerve ring, 65μ. The anterior portion of the esophagus is slender, averaging about 11μ in width; its length is 200μ. The posterior end of the esophagus is 1 mm. from the anterior end of the body. The width of its posterior portion varies from about 25μ a short distance behind its junction with the anterior portion to about 50μ at its posterior end. The width of the body at the base of the esophagus is 70μ and is practically the same at the middle of the body. The intestine, nearly uniform in diameter, has a maximum width of about 40μ. The anus is 100μ from the tip of the tail, and the diameter of the body (dorsoventral) at the anus is about 33μ. The tail is slightly

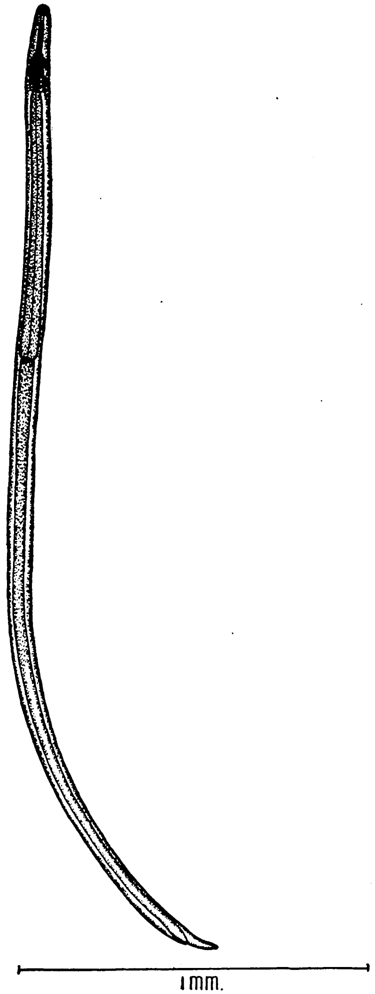


FIG. 17.—*Habronema muscæ.* Larva (Stage 6) from head of newly emerged fly. × 46. Original.

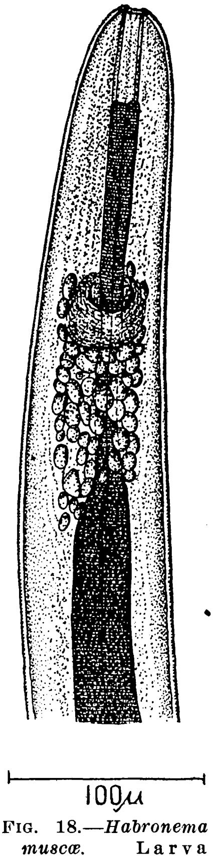


FIG. 18.—*Habronema muscæ.* Larva (Stage 6) from head of newly emerged fly. Anterior end of worm shown in fig. 17. × 250. Original.

bent dorsalwards. Under high magnification a few small short longitudinal ridges may be seen on the inner surface of the pharynx at its anterior end. These are faintly evident in figure 18. The mass of nuclei posterior of the nerve ring shown in this figure are a conspicuous feature of the worm at this stage. It is these nuclei which were misinterpreted by Carter as reproductive organs.

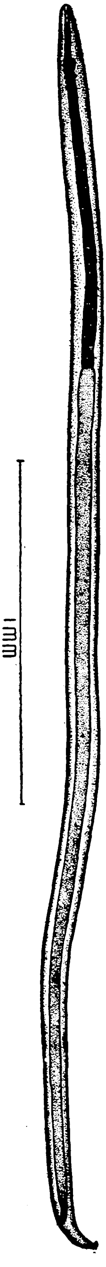


FIG. 20.—*Habronema muscæ*. Larva (Stage 6) from stomach of horse. × 45. Original.

In horses: The final larval stage in the fly is the first stage of development in which the worm is found in the horse. Worms in this stage were found among numerous individuals collected from the stomach of a horse, September 7, 1911, at Omaha, Nebr. Examination of the worms from this horse showed two or three specimens of a *Trichostrongylus*, but most of them were filarioid worms in various stages of growth, the adults all belonging to a single species very similar to *Spiroptera microstoma*. The relative size of several worms from this horse are shown in figure 23, *c–i*.

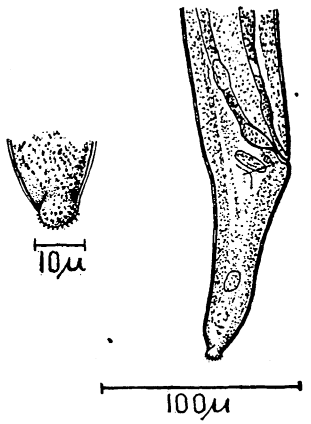


FIG. 19.—*Habronema muscæ*. Larva (Stage 6) from newly emerged fly. Posterior end. × 260. Drawing at left shows spinose tip of tail more highly magnified. × 650. Original.

The fact that the adults were all of one species, and that the younger stages formed a series between the adult on one hand and the larval *Habronema muscæ* on the other showed quite clearly that *Habronema muscæ* of the fly is the larval stage of a parasite whose adult occurs in the stomach of the horse. This parasite, as shown later, though similar to *Spiroptera microstoma*, is distinctly different from this form. Under the rules of nomenclature it takes the name *Habronema muscæ*, and *Spiroptera microstoma*, with which it is congeneric, becomes *Habronema microstoma*, as noted on my preliminary report (Ransom, 1911).

It is fair to presume that *Habronema microstoma* has a life history similar to that of *H. muscæ*, and as already noted it may be that the form from *Stomoxys calcitrans* called *Filaria stomoxeos* by Linstow is the larval stage of *H. microstoma*.

The infection of horses with *H. muscæ* is apparently brought about by the swallowing of infested flies. That horses actually swallow flies is a fact evident to anyone who has observed horses during the fly season. The swallowing of dead flies as a possible method of infection has already been mentioned, and the possibility that the worms may escape from the proboscis while the fly is feeding on the moist mucous membrane of a horse's mouth has also been noted.

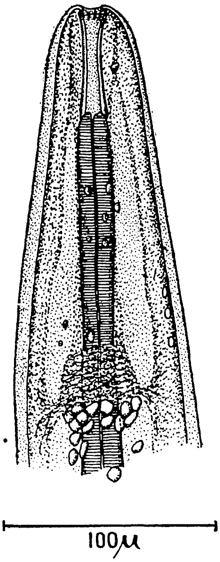


FIG. 21. — *Habronema muscæ*. Larva (Stage 6) from stomach of horse. Anterior end. × 275. Original.

The larva shown in figures 20 to 22 exhibits no further development beyond the final stage of development found in the fly except a slight increase in length and thickness, and it is considered unlikely that an intervening molt has occurred. The length is 3.7 mm. The pharynx is 45μ long. Width of body at the base of the pharynx, 50μ. Nerve ring 160μ from the anterior end of the body. Width of body at nerve ring 80μ. Length of first part of esophagus 175μ. Base of esophagus 1.05 mm. from anterior end of body. Width of body at base of esophagus and at middle of body 90μ; anus 125μ from the tip of the tail. Diameter (dorsal-ventral) of body at anus, 50μ. The little ridges at the anterior end of the pharynx, sometimes apparent in larvæ from flies, were plainly evident in this specimen. The tail is bent dorsalwards as in the final larval stage found in flies. This worm is evidently nearly ready to molt. The worm shown in figure 23, *c*, which is in the same stage of development, though somewhat smaller, measuring only 3.5 mm. in length, is also ready to molt.

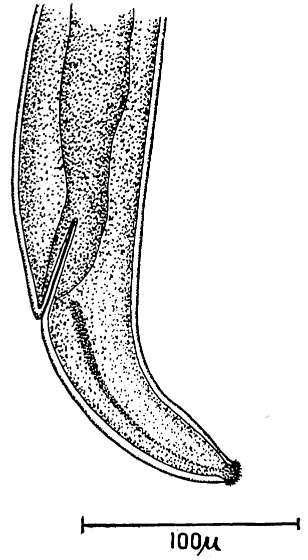


FIG. 22.—*Habronema muscæ*. Larva (Stage 6) from stomach of horse. Posterior end. × 275. Original.

LATER IMMATURE STAGES IN HORSES.

The first molt of the worm during its development in the horse is accompanied by no appreciable change in structure. Even the spiny condition of the tip of the tail is retained. Such a worm is shown in figure 23, *d*. The esophagus is relatively a little shorter, and, as shown in figure 23, *e–i*, becomes relatively still shorter in later stages of development. In stages later than that shown in figure 23, *d*, the spiny knobbed tail is no longer present.

Apparently, at least four molts, and possibly five, occur in the development of the worm in the horse, between the earliest stage

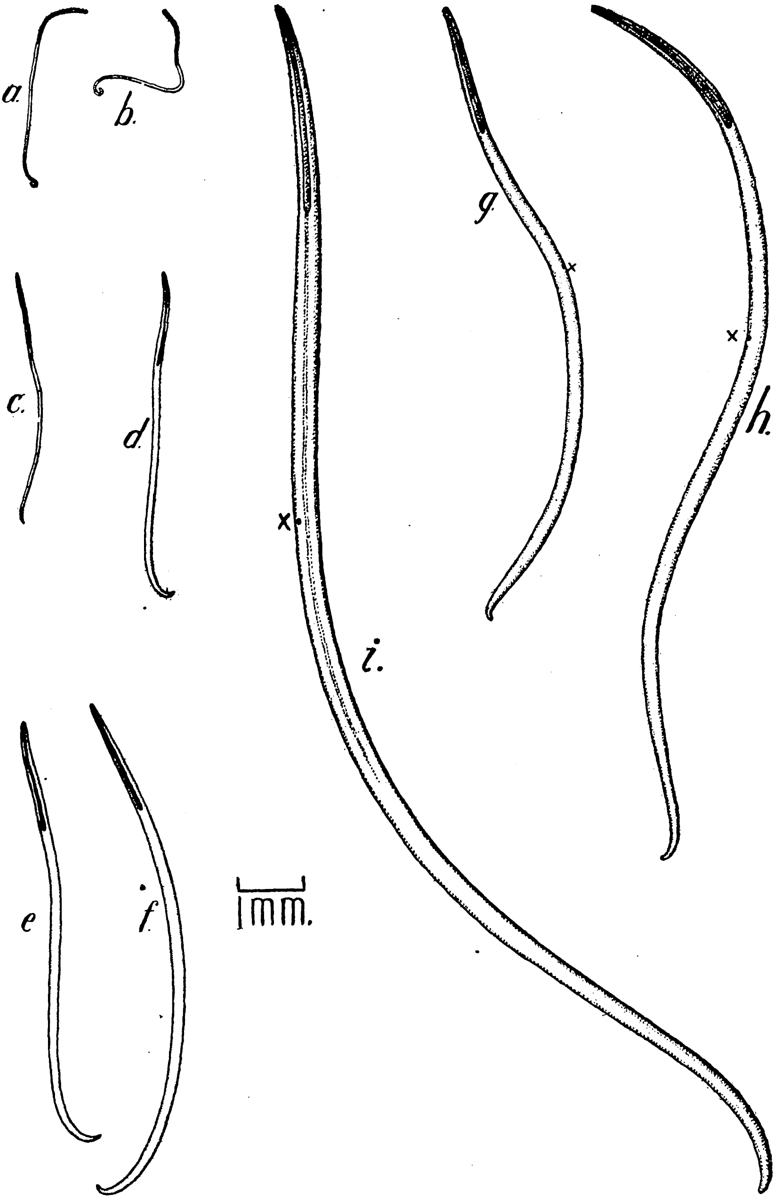


FIG. 23.—*Habronema muscæ.* Larvæ, immature stages, and adults. *a, b,* larvæ (Stage 6) from fly; *c,* larva (Stage 6) from stomach of horse; *d,* larva (later stage) from stomach of horse; *e, f, g,* later immature stages from stomach of horse; *h, i,* adult females from of horse. X indicates position of vulva. × 9. Original.

and the adult. All five of the worms shown in figure 23, *c–g*, are in process of molting. The two shown in figure 23, *c*, *d*, have spiny tails, a character which has disappeared in those shown in figure 23, *c–g*.

The one shown in figure 23, *f*, has the position of the vulva evident beneath the old cuticle. A stage closely following the one shown in figure 23, *f*, is shown in figure 23, *g*. In this worm the vulva opened to the exterior.

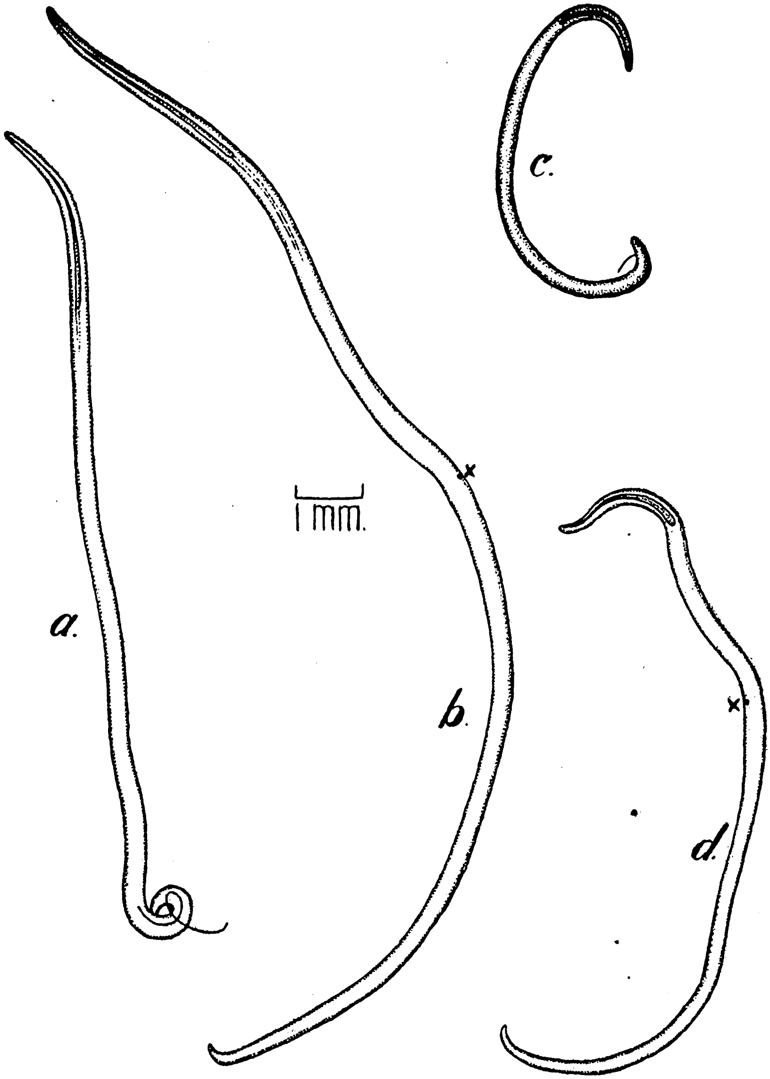


FIG. 24.—*Habronema muscæ.* Adult males (*a, c*) and females (*b, d*). X indicates position of vulva. × 9. Original.

ADULT.

The adult male *Habronema muscæ* (fig. 24, *a, c*) varies in length from 8 to 14 mm., and from 250 to 300μ in maximum width, which is attained near the posterior end. The length of the adult female (fig. 24, *b, d;* fig. 23, *h, i*) varies from 13 to 22 mm., and the width in the region of the vulva from 250 to 400μ. *Habronema microstoma*, in the case of the male (fig. 25, *a*, *c*), varies in length from 9 to 16

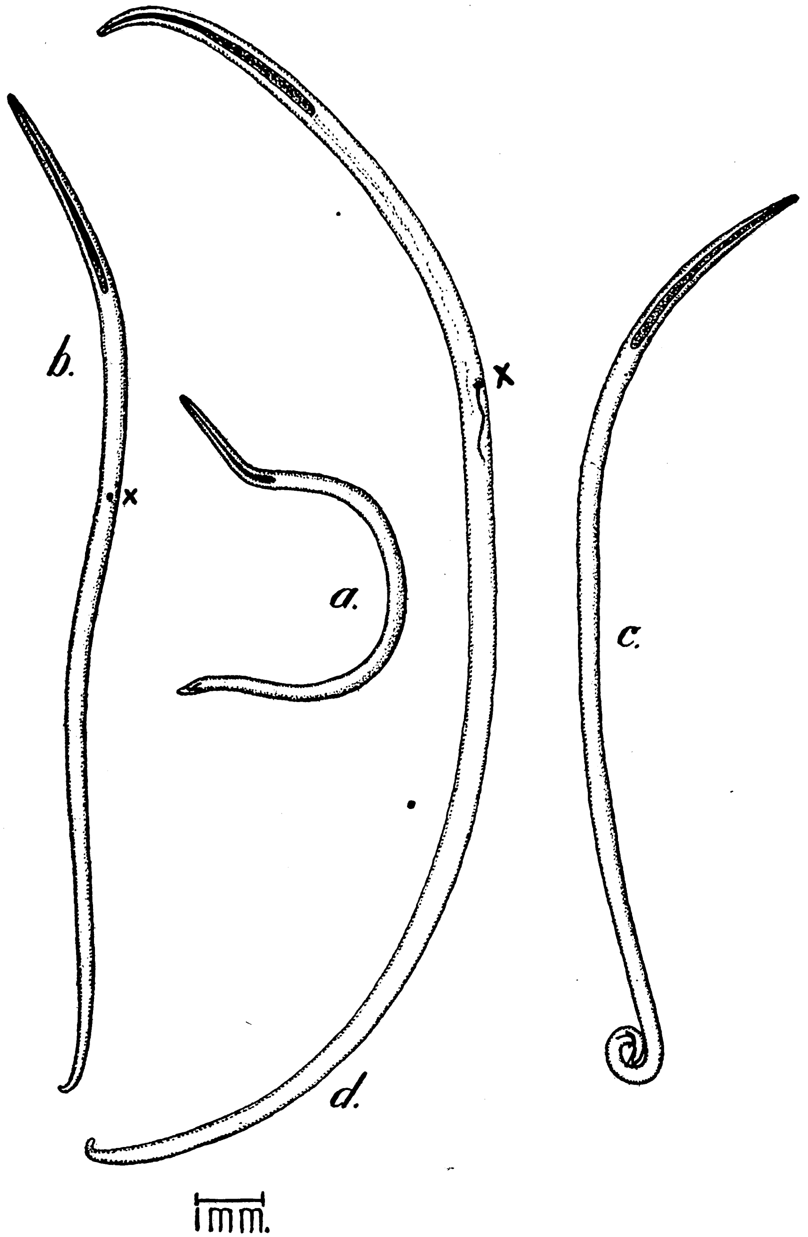


FIG. 25.—*Habronema microstoma*. Adult males (*a*, *c*) and females (*b*, *d*). X indicates position of vulva. × 9. Original.

mm. (11 to 22 mm., Schneider) and from 250 to 300μ in maximum width, which is attained at a point some distance posterior of the base of the esophagus. The female *H. microstoma* (fig. 25, *b*, *d*) varies in length from 15 to 25 mm. and in width (at the vulva) from 330 to 500μ. *Habronema muscæ* thus averages somewhat smaller in size than *H. microstoma*. In both species there is a marked transverse striation or corrugation of the cuticle. The general plan of the head, mouth parts, pharynx, and esophagus is the same in both *H. muscæ* (figs. 26, 27) and *H. microstoma* (figs. 28, 29), but in the details of these structures there are certain distinct differences. The head of the latter has a broader, squarer, more truncate appearance. In both the mouth is bordered by 2 lateral trilobed lips, or if differently interpreted by 2 lateral and 4 submedian lips. The head is armed with 2 lateral and 4 submedian papillæ, the latter being situated somewhat posterior of the former. From a lateral view the middle lobe of each lateral lip presents a nearly quadrangular outline, with the lateral papilla near its anterior border.

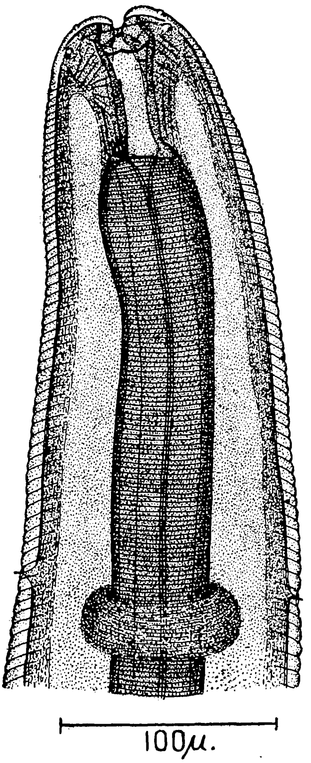


FIG. 26.—*Habronema muscæ*. Anterior end of adult. Drawn from specimen shown in fig. 23, *h*. × 280. Original.

The pharynx whose structure is somewhat complicated is smaller and relatively more slender in *H. muscæ* than in *H. microstoma*. In both species it is compressed laterally. In *H. microstoma* a tridentate process, not present in *H. muscæ*, projects into the mouth cavity from the dorsal wall of the anterior part of the pharynx, and a similar process is present on the ventral wall.

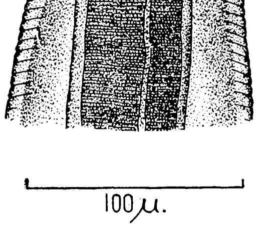


FIG. 27.—*Habronema muscæ*. Anterior end of adult. Lateral view. Drawn from specimen shown in fig. 24, *b*. × 280. Original.

In the adult as in the larval *H. muscæ* the esophagus is distinctly divided into two parts, a narrow, short anterior portion and a broader, longer posterior portion. The slender anterior portion is surrounded by a nerve ring about 300μ (in the female) from the anterior end of the body, and in the region of the nerve ring there is a pair of short, slender, bristlelike cervical papillæ (fig. 26). The nerve ring and cervical papillæ in *H. microstoma* are located 300 to 350μ (in the female) from the anterior end of the body (fig. 28). The distance from the anterior end of the body to the base of the esophagus varied in several specimens (females) of *H. muscæ* from 2.3 to 3.5 mm. In females of *H. microstoma* this distance varied from 3 to 3.8 mm.

In both *H. muscæ* and *H. microstoma* a narrow lateral membrane begins posterior of the left cervical papilla and extends backward along the left side of the body. In the male it extends to or even beyond the middle of the body and in the female it ends within a short distance in front of or behind the vulva. A lateral membrane on the right side of the body is lacking. The unusual circumstance in which a lateral membrane occurs on one side of the body and a corresponding membrane is absent from the other side has been noted in the case of *Arduenna strongylina* by Schneider (1866 *a*) and others.

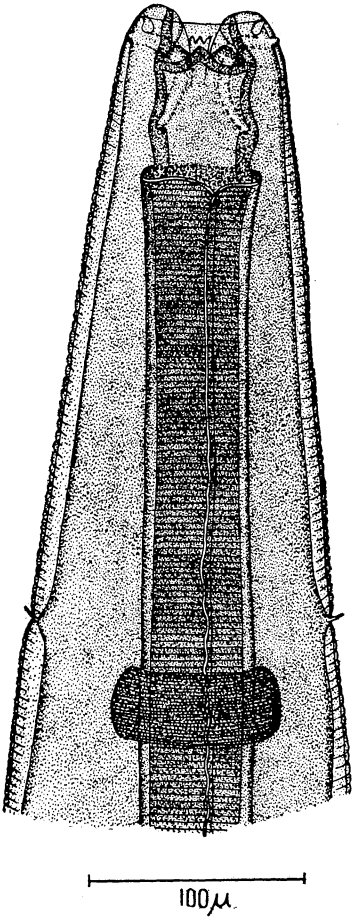


FIG. 28.—*Habronema microstoma.* Anterior end of adult. Drawn from specimen shown in fig. 25, *b*. × 280. Original.

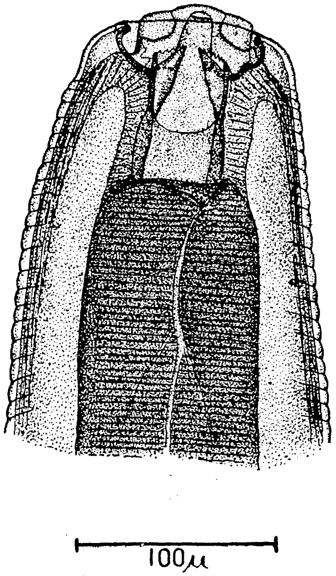


FIG. 29.—*Habronema microstoma.* Anterior end of adult. Lateral view. Drawn from specimen shown in fig. 25, *d*. × 260. Original.

The tail of the male curves ventrally in both *H. muscæ* and *H. microstoma*, usually describing a single turn of a spiral (figs. 30, 31). Narrow, almost symmetrical, bursal wings are present, measuring about 500μ in length and extending to the tip of the tail in both species. Stalked genital papillæ, pre-anal and post-anal, are present.

In *H. muscæ* there are four pairs of pre-anal papillæ, two pairs of which are ad-anal rather than pre-anal. On the right side of the bursa there is one post-anal papilla, about half way between the anus and the tip of the tail, and on the left side a papilla in a corresponding location. A short distance in front of the latter and nearer the median line is another papilla. A corresponding papilla on the right side of the bursa is lacking. The arrangement of the papillæ will be better understood from the figures than from a description (figs. 30, 32).

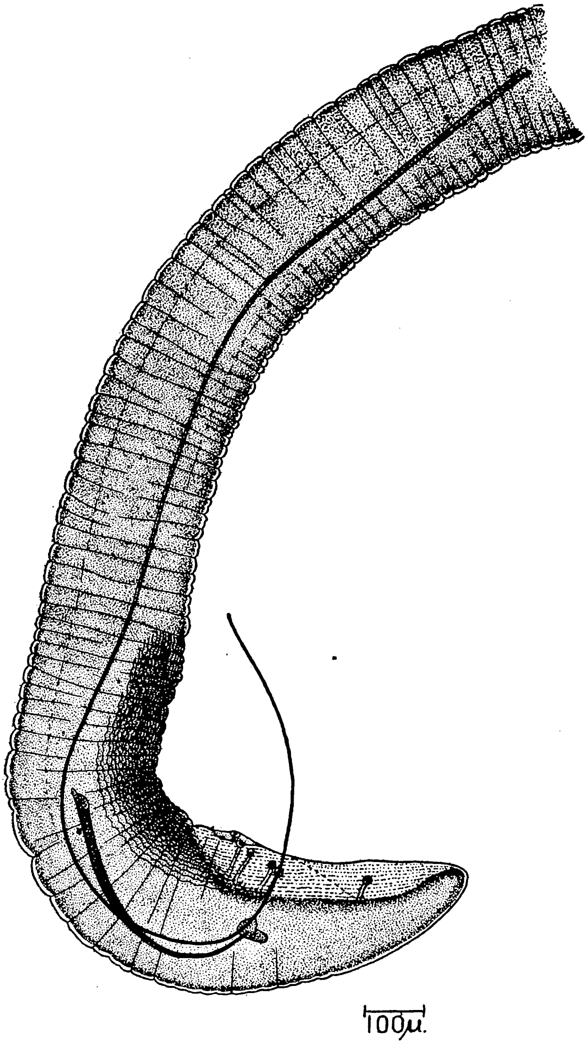


FIG. 30.—*Habronema muscæ*. Tail of male. Lateral view. Drawn from specimen shown in fig. 24, *c*. × 80. Original.

In *H. microstoma* there are four pairs of pre-anal papillæ, those of the left side being somewhat further anterior than those of the right side. Instead of three post-anal papillæ, as in *H. muscæ*, there are

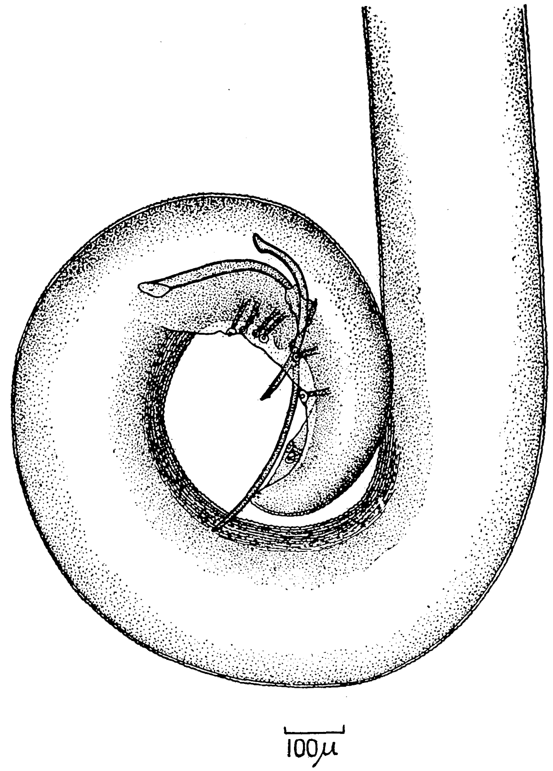


FIG. 31.—*Hebronema microstoma.* Tail of male. Lateral view. Drawn from specimen shown in fig. 25, *c.* × 80. Original.

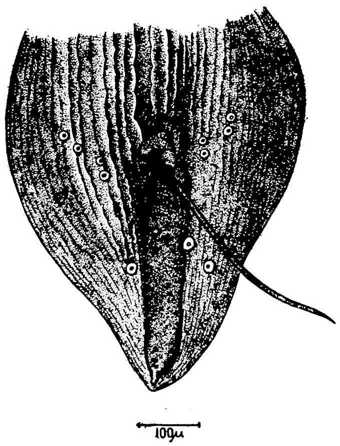


FIG. 32.—*Habronema muscæ.* Tail of male. Ventral view. × 80. Original

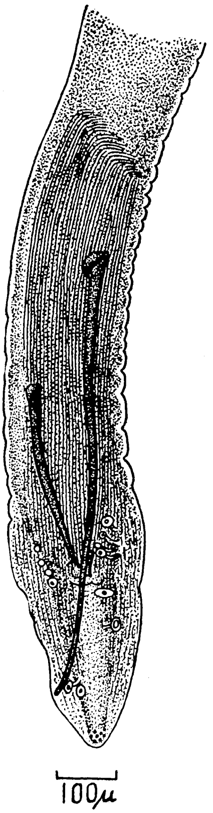


FIG. 33.—*Habronema microstoma.* Tail of male. Ventral view. Drawn from specimen shown in fig. 25, *a.* × 80. Original.

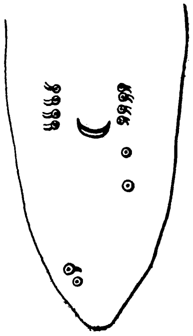


FIG. 34.—*Habronema microstoma.* Tail of male. Ventral view. × 62. After Schneider, 1866 *a*, p. 98.

four. On the left side there is one near the anus, and another a short distance posterior of this one. The two post-anal papillæ on the right side are close together and not far removed from the tip of the tail. The arrangement of the genital papillæ is shown in the figures (figs. 31, 33, 34).

In both *H. muscæ* and *H. microstoma* the ventral surface of the tip of the tail of the male is supplied with a cluster of very small papillæ, six of which are somewhat more prominent than the others.

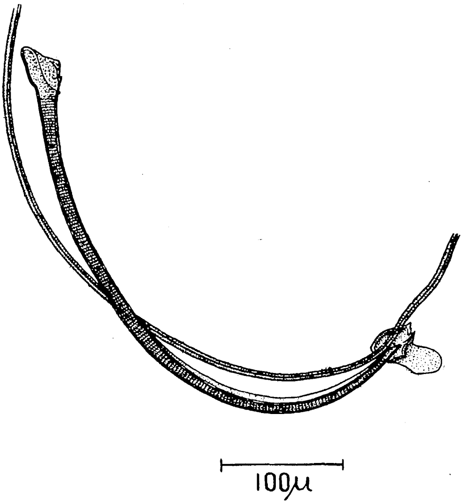


FIG. 35.—*Habronema muscæ.* Spicules and gubernaculum of male. Only a portion of the left spicule is shown. Drawn from specimen shown in figs. 24, *c*, and 30. × 160. Original.

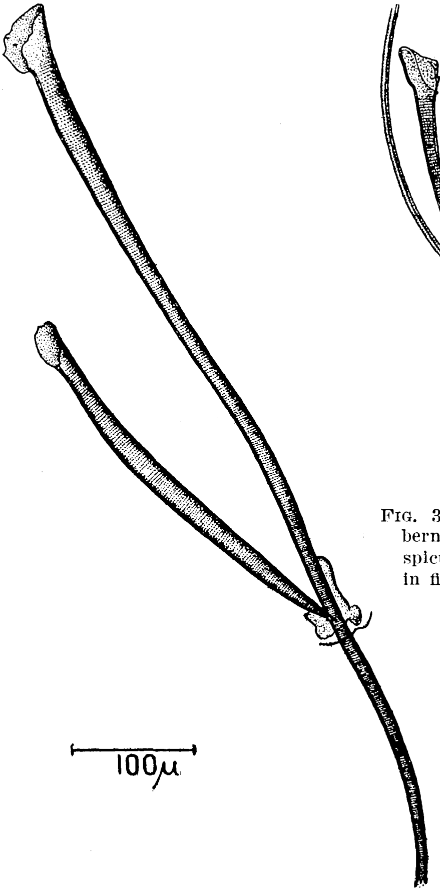


FIG. 36.—*Habronema microstoma.* Spicules and gubernaculum of male. Drawn from specimen shown in figs. 25, *a*, and 33. × 160. Original.

In all, there are 10 or 12 of these papillæ. They are considerably larger and more conspicuous in *H. muscæ* than in *H. microstoma.*

The cuticle on the ventral surface of the posterior portion of the body of the male, beginning about a millimeter to a millimeter and a half from the tip of the tail, is marked by numerous longitudinal scalloped ridges; in fact, the entire ventral face of the bursa is marked with delicate longitudinal ridges and small vesicular excrescences having a linear arrangement.

The spicules in *H. muscæ* (figs. 30, 35) are quite dissimilar. The left spicule is long, slender, about 2.5 mm. in length, about 10μ in diameter near its proximal end, tapering to a sharp point, and measures about 5μ in diameter at its middle. The right spicule is shorter and thicker, about 500μ long, tapering from a thickness of about 20μ near its proximal end to a point posteriorly, and measuring about 10μ at its middle. Near the anal opening the spicules are surrounded by a small, irregularly shaped gubernaculum.

The left spicule of *H. microstoma* (figs. 31, 33, 36) is much shorter and thicker than that of *H. muscæ*. It measures about 800μ in length, tapering from a diameter of about 20μ near its anterior end to a diameter of 8μ at its posterior end, and measuring about 15μ in diameter at its middle. The right spicule has a length of about 350μ, and a diameter of about 15μ near its anterior end. It increases in thickness posteriorly, reach-

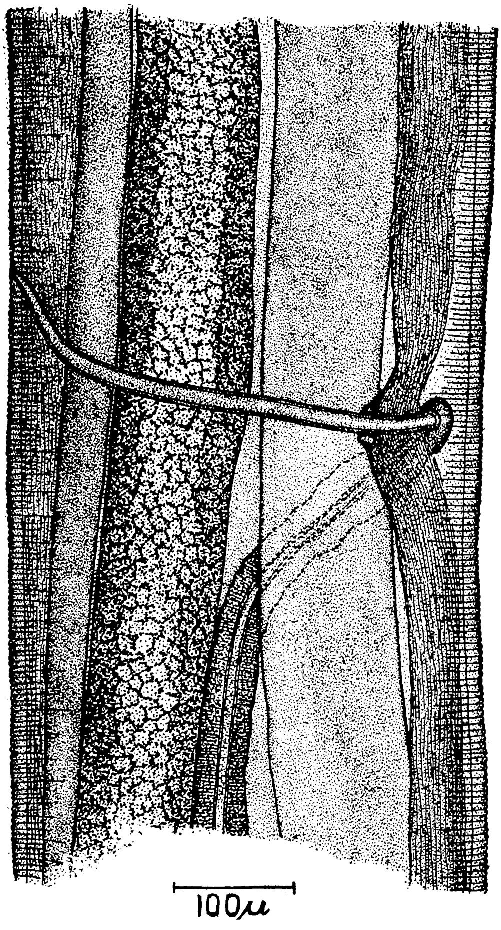


FIG. 37.—*Habronema muscæ.* Region of vulva of female. Drawn from specimen shown in fig. 23, *i.* × 160. Original.

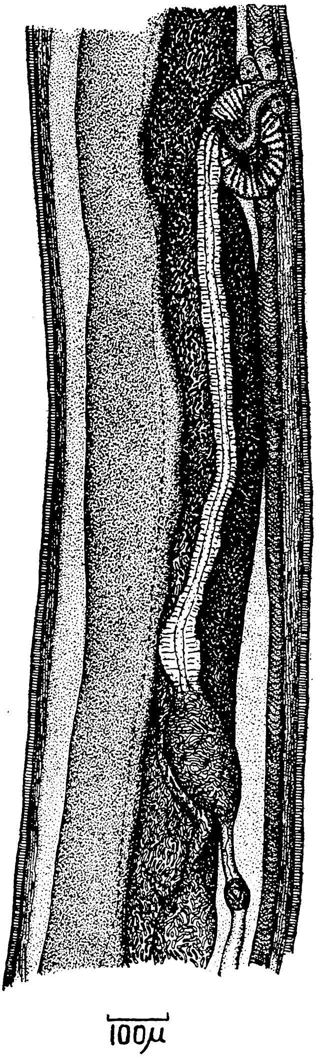


FIG. 38.—*Habronema microstoma:* Region of vulva of female. Drawn from specimen shown in fig. 25, *d.* × 80. Original.

ing a diameter of about 20μ at its middle, then decreases again, and terminates in a point with a small barb about 6μ from the tip. Near the anus the spicules, as in *H. muscæ*, are surrounded by a small, irregularly shaped gubernaculum.

In *H. muscæ* the vulva is located about a third of the length of the body from the anterior end (figs. 23, 24, *x*); in *H. microstoma* the distance of the vulva from the anterior end is slightly over a third the body length (fig. 25, *x*). The vulva of *H. muscæ* is very small (fig. 37), and is displaced dorsalward out of the usual mid-ventral position. It may be dorsal in position, or may even be displaced still further and be located on the left side of the body a slight distance dorsal of the lateral membrane. A somewhat similar displacement of the vulva has been noted by Ciurea in *Arduenna strongylina.* The distal portion of the vagina measures not over 15μ in diameter and is without a muscular sheath. From the vulva it passes transversely halfway or more (according to the degree of displacement of the vulva) around the body beneath the cuticle in the superficial portion of the body wall, then enters the body cavity, becoming clothed with a muscular layer, and passes posteriorly, joining the two uteri about 1.5 mm. posterior of the vulva. Including the muscular sheath, the diameter of the vagina after it enters the body cavity is about 4.5μ.

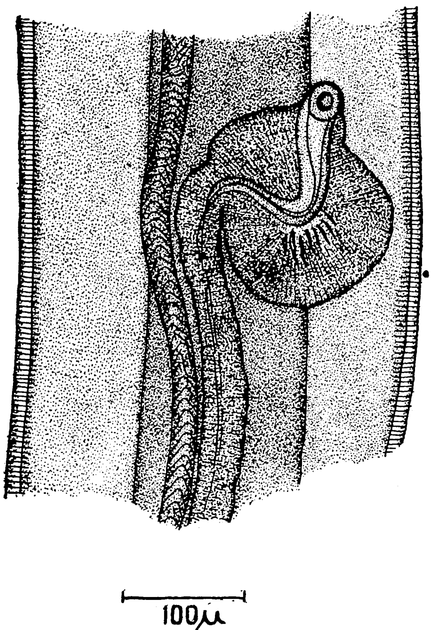


FIG. 39.—*Habronema microstoma.* Region of vulva of female. Drawn from specimen shown in figs. 25, *b*, and 29. × 160. Original.

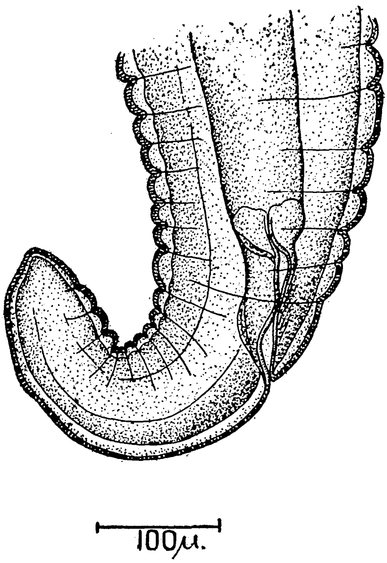


FIG. 40.—*Habronema muscæ.* Tail of female. Lateral view. × 160. Original.

In *H. microstoma* the vulva is rather large, its diameter, including its chitinous margin, being about 30μ (figs. 38, 39). It is not displaced more than very slightly from the mid-ventral position, if at all. The vagina passes inward and backward, then curves forward for a very short distance, and backward again, entering the body cavity, and continuing then in a straight course posteriorly to join the terminal portion of the two uteri. The vagina, in the region of the short **S**-shaped curve, is surrounded by a globular mass of muscular tissue. This muscular mass, 150 to 200μ in diameter, is a conspicuous structure in transparent specimens, located immediately posterior of the vulva. The vagina, throughout its course posteriorly from the globular muscle mass which surrounds its distal portion to the uteri, is surrounded by a muscular layer. Including this layer, its diameter is from 40 to 50μ. The length of the vagina, measured in a straight line from the vulva to the point where it joins the uteri, is about 1 mm.

H. muscæ is thus quite different from *H. microstoma* with regard to the vulva and vagina. The vulva is much smaller, the vagina passes halfway around the body before entering the body cavity, and is without the distal **S**-shaped curve surrounded by a muscle bulb. These characteristic features of *H. muscæ* are already evident in young worms 7 mm. long, which have not yet undergone the fourth molt in their development in the horse.

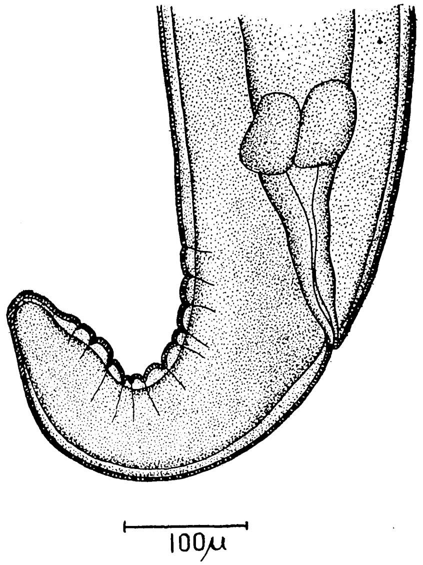


FIG. 41.—*Habronema microstoma.* Tail of female. Lateral view. Drawn from specimen shown in figs. 25, *b*, 29, and 39. × 160. Original.

The tail of the female is very similar in *H. muscæ* (fig. 40) and *H. microstoma* (fig. 41), rather plump, with rounded tip, and more or less curved dorsalward, the post-anal portion measuring 300 to 350μ in length in *H. muscæ* and slightly more in *H. microstoma.*

ADDENDUM.

Since July 15, 1912, when the manuscript of this bulletin was completed and submitted for publication, two articles containing references to *Habronema* have come to hand.

Seurat (1912, 778) reports the occurrence of both *H. muscæ* and *H. microstoma* in horses and mules in Algiers, and describes and figures the ovijector in both species.

Johnston (1912, 76) reports the presence of *Habronema muscæ* in *Musca domestica* at Brisbane and in *M. domestica* and *Stomoxys calcitrans* at Sydney, Australia.

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